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Contribution of green energy sources to electrical power production of Turkey: A review

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Abstract

Green power products may be seen as a means of fostering renewable energy sources (RES) because they create and channel consumer demand for environmentally sound power generation. Turkey also has a large potential for renewable energy exploitation in a number of areas. Clean, domestic and renewable energy is commonly accepted as the key for future life, not only for Turkey but also for the world. The renewable energy contribution in the total primary energy production is insignificant. The alternative and renewable energy systems have been neglected so far in Turkey but must be included in the new energy programs. In this context, Renewable Energy Law was enacted in 2005 in order to encourage renewable-based generation in competitive market conditions. Supporting mechanisms such as feed-in tariffs and purchase obligation are defined in the law, in conformity with the EU legislation and practice. These mechanisms are envisaged to facilitate the development of power plants based on RES.

Keywords: Turkey; Green power; Green electricity; Renewable energy

Contents

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1. Introduction

Green power products may be seen as a means of fostering renewable energy sources (RES) because they create and channel consumer demand for environmentally sound power generation [1]. There has been interest in electricity from renewable sources named green electricity or green pool as a special market. The term *green energy* is also used for green energy produced from cogeneration, energy from municipal waste, natural gas and even conventional energy sources. Green power refers to electricity supplied from more readily RES than traditional electrical power sources [2].

The electricity sector in many countries is one of the largest contributors to greenhouse gas emissions, and therefore a major target of climate change regulation [3]. The environmental advantages of the production and use of green electricity seem to be clear. Using green energy sources, like hydro, biomass, geothermal and wind energy, in electricity production reduces carbon dioxide (CO_2) emissions. Emissions such as sulfur dioxide (SO_2), CO_2 and nitrogen oxides (NO_x) are reduced considerably, and the production and use of green electricity contributes to diminishing the green house effect [2].

Renewable energies are considered as an essential element of any strategy for sustainable energy development. The poor in the developing world without access to modern energies are regarded as a major market for renewable energies [4]. The utilization of non-renewable energy sources in the developing countries with low levels of technological knowledge not only results in environmental pollution but also confronts us with the dilemma of a rapid rate of depletion of such invaluable resources while renewable energy sources can serve us indefinitely with minimal environmental impacts as compared with nuclear and fossil fuels. That is why a gradual replacement of non-renewable energy sources with renewable ones has been of major interest for most countries and poses as one of the most important issues of today [5].

RES are becoming attractive solutions for clean and sustainable energy needs of Turkey [6]. Clean, domestic and renewable energy is commonly accepted as the key for future life, not only for Turkey but also for the world. This is primarily because RES have some advantages when compared to fossil fuels. Turkey has to adopt new long-term energy strategies to reduce the share of fossil fuels in the primary energy consumption. A major dilemma now faced by Turkey is how to invest in new electric power capacity while at the same time adhering to foreign debt ceilings under lending rules set by the International Monetary Fund [7].

The renewable energy contribution in the total primary energy production is insignificant. The alternative and renewable energy systems have been neglected so far in Turkey but must be included in the new energy programs [8]. According to the estimates

of the Turkish Ministry of Energy and National Sources, an increase in the production of renewable energy is expected, while a decrease is predicted in total energy requirements [9]. In this context, the Renewable Energy Law was enacted in 2005 in order to encourage renewable-based generation in competitive market conditions. Supporting mechanisms such as feed-in tariffs and purchase obligation are defined in the law, in conformity with the EU legislation and practice. These mechanisms are envisaged to facilitate the development of power plants based on RES [10]. Furthermore, the Law gives the Council of Ministers the authority to increase the price applicable to RES by a maximum of 20% at the beginning of each year. The Renewable Energy Law is a first step towards implementation of the renewables acquis. However, the Law does not set a target for electricity generated from RES by 2010, as foreseen by the relevant directive. Given Turkey's significant untapped potential for RES, it should set itself an ambitious target for their further development, including geothermal energy. Turkey would be recommended to develop an overall strategy for RES [11].

2. Turkey's renewable energy sources

Turkey also has a large potential for renewable energy exploitation in a number of areas. Turkey has abundant reserves of renewable energy, such as hydro, solar, wind, biomass and geothermal. The benefits of exploiting these sources would be enormous [12]:

- by relying completely on indigenous resources, renewable energy would reduce reliance on imported fuels and enhance Turkey's energy security;
- the environmental impact of renewable technologies is far less than that of nuclear and fossil fuel power plants. There are no emissions of greenhouse gases of toxic wastes;
- the cost of electricity from some RES is already competitive with many conventional technologies and is dropping rapidly;
- renewable technologies have no fuel costs and are virtually inexhaustible.

2.1. Hydro energy sources

The water in rivers and streams can be captured and turned into hydropower, also called hydroelectric power. Hydropower is also inexpensive, and like many other RES, it does not produce air pollution [13].

Hydroelectric power and especially small hydroelectric power are emphasized as Turkey's renewable energy sources [14]. In recent decades, Turkey has made great strides in water resource development for irrigation, power generation, flood control and other purposes. The creation of dams and reservoirs has enabled Turkey to save the water from its brief seasons of rainfall to use throughout the year for irrigation, energy, drinking and sanitation [15]. The objective of this activity is to check dam, hydroelectric power plant (HEPP) and related power generation facilities projects which will be implemented under the State Hydraulic Works (DSI in Turkish initials) control, to check the construction stages of the dam and hydroelectric power plants, and to examine and approve dam projects designed by other public and private organizations and required to be approved by DSI [16].

Annual rainfall varies from 220 to 2500 mm in Turkey with an average of 643 mm, which means total volume km^3. Turkey's water and land sources at the base of river zone are

Table 1
Water and energy potential of selected river basins in Turkey [16,17]

Name of basin	Land area (km^2)	Average rainfall (mm/yr)	Number of dam	Stored water (hm^3)	Installed capacity (MW)	Average generation (GWh)
Susurluk	22,399	712	25	3509	537	1697
Gediz	18,000	603	14	3369	250	425
B.Menderes	24,976	664	19	2722	215	848
B.Akdeniz	20,953	876	24	1837	675	2495
Antalya	19,577	1000	15	2885	1252	4411
Sakarya	58,160	525	45	6920	1063	2362
B.Karadeniz	29,598	811	24	2519	593	2110
Yeşilırmak	36,114	497	45	6302	1658	6468
Kızılırmak	78,180	446	82	21,260	2007	6512
D.Akdeniz	22,048	745	11	9122	1496	5176
Seyhan	20,450	624	18	6125	1886	7117
Ceyhan	21,982	732	25	7720	1409	4634
Euphrates	127,304	540	83	112,792	9845	38,939
D.Karadeniz	24,077	1198	43	1523	3323	10,927
Çoruh	19,872	692	20	7544	3227	10,614
Aras	27,548	432	20	4085	585	2291
Tigris	57,614	807	36	30,295	5082	16,876

given in Table 1 [17]. The most important rivers are the Firat River (Euphrates) and Dicle River (Tigris), both of which are transboundary rivers originating in Turkey and discharging into the Persian (Arabian) [18]. The Euphrates and Tigris rivers represent over 28% of the nation's water supply by rivers, and the economically irrigable areas in the region make up 20% of those for the whole country [15]. In 1977, these two basin projects were given the single title of the Southeastern Anatolia Project (GAP in Turkish initials). Thirteen projects were prepared to develop the rich water resources (the rivers of Euphrates and Tigris) of the region for irrigation and power generation purposes. Seven of these projects are in the basin of the Euphrates and six in that of the Tigris. These projects envisage the construction of 22 dams and 19 power plants, generation of 27 billion kWh of energy a year over an installed capacity of 7485 megawatts (MW), and irrigation that will cover 1.7 million hectares of land [18]. Major Turkish hydro dams as part of the GAP include: Ataturk (2400 MW capacity); Karakaya (1800 MW); Ilisu (1200 MW); the largest hydro project on the Tigris River, but highly controversial due to environmental concerns; Cizre (240 MW); Silvan/Kayseri (240 MW); Hakkari (208 MW); Alpaslan II (200 MW); Batman (198 MW); Konaktepe (180 MW); and Karkamis (180 MW) [15,16,19].

2.2. Geothermal energy sources

Turkey has significant potential for geothermal power production, possessing one-eighth of the world's total geothermal potential [20]. The main utilization of geothermal energy in Turkey is in domestic heating, greenhouses, and spas and thermal resorts installed for balneological purposes [21]. The overall geothermal potential in Turkey is about 38,000 MW (electric and thermal) (Table 2). Of this potential, around 88% is appropriate for thermal use (temperature less than 423 K) and the remainder for electricity production (temperature more than 423 K) [20,22].

Table 2
Turkey's geothermal energy potential [20,21,23]

	Proven (MW)	Probably and possible (MW)
Heat (<2273 K, low enthalpy fields) (MWt)	2250	31,100
Electricity (>2273 K, high enthalpy fields) (MWe)	200	4500

Table 3
Turkey's hot field resources [23]

Field	Temperature range (K)
Izmir–Balcova	353–399
Izmir–Seferihisar	410–426
Kutahya–Simav	426–435
Aydin–Salavatli	435–444
Canakkale–Tuzla	413–473
Denizli–Kizildere	463–485
Aydin–Germencik	473–505

Geothermal energy is clean, cheap and renewable, and can be utilized in various forms and electricity generation [23]. Geothermal energy is being used for electricity production and it has direct usage in Turkey, which is among the first five countries in the world for the geothermal direct usage applications [6]. The first geothermal researches and investigations in Turkey started by Turkey Mineral Research and Exploration Institute (MTA in Turkish initials) in 1960s. Upon this, 170 geothermal fields have been discovered by MTA, where 95% of them are low–medium enthalpy fields, which are suitable mostly for direct-use applications [20,22,24]. As seen in Table 3, high-temperature geothermal fields suitable for conventional electricity generation are Aydin–Germencik (473–505 K), Denizli–Kizildere (463–485 K), Canakkale–Tuzla (413–473 K), Aydin–Salavatli (435–444 K), Kutahya–Simav (426–435 K) and Izmir–Seferihisar (410–426 K) [23].

This means that considerable studies on geothermal energy could be conducted in order to increase the energy supply and to reduce atmospheric pollution in Turkey. Although Turkey is among the countries which have a high potential of geothermal energy in the world, the use of this energy for electricity generation is rather low [21].

2.3. Wind energy sources

Wind energy is the fastest growing energy source in the world and wind power is one of the most widely used alternative sources of energy today. It is a clean and renewable source of electricity [25]. In Turkey, wind energy has great potential [26]. Turkey's total theoretically available potential for wind power may be around 88,000 MW annually, with particularly attractive areas for wind located along Turkey's west coast and in southeastern Anatolia [27]. Table 4 shows Turkey's wind energy potential over various regions.

Turkey's wind energy potential could not be definitely calculated due to the insufficiency of available data. There are a number of regions with relatively high wind speeds in

Table 4
Turkey's wind energy potential over various regions [20,25,26,29]

Region	Annual average wind speed (m/s)	Annual average wind density (W/m^2)
Southern Anatolia	2.69	29.3
Mediterranean	2.45	21.4
Aegean	2.65	23.5
CentralAnatolia	2.46	20.1
East Anatolia	2.12	13.2
The Marmara	3.29	51.9
Black Sea	2.38	21.3
Mean of Turkey	2.58	25.8

Turkey. The most attractive regions for wind energy utilization are the Marmara, Southeast Anatolian and Aegean [20,26,28,29]. The highest wind speed is 6.36 m/ and the highest wind density is 319.5 W/m^2 s in Bozcaada. However, the highest wind speed values given in the literature are 6.4 m/s in Karaburun and Karabiga, 7 m/s in Senkoy and 7.1 m/s in Nurdagi. The highest wind density recorded is 152.6 W/m^2 in Bandırma [28,29].

The first wind power plant (wind farm), located in Cesme, Izmir, was commissioned in February 2001 in accordance with the auto production scheme. This plant has a total installed capacity of 1.5 MW and provides 2.5–3 million kWh of electricity annually. The second Build–operate–transfer (BOT)-modeled windmill park, located in Alacati, Izmir, has been operating since November 1998. This wind power plant had 12 wind turbines with a total installed capacity of 7.2 MW. On the island of Bozcaada, the third wind power plant (called BORES) was connected to the grid in July 2000. The plant is currently the biggest one in the country and has a total installed capacity of 10.2 MW [30]. Currently, wind energy projects are concentrated in the Aegean region (16 projects) and the Marmara region (nine projects) [23].

2.4. *Solar energy sources*

Among the alternative clean energy resources in Turkey, the most important one is the solar energy. Turkey has a more chance than the other countries in terms of solar energy potential due to its geographical situation [20]. Turkey's gross solar potential is calculated as 88 billion tons of oil equivalents (toe) per year, of which 40% can be, used economically. Three-fourths of the economically usable potential is efficient for thermal use and the remainder for electricity production [31]. Solar radiation and sunshine duration in various regions of Turkey are given in Table 5. The average solar radiation is 309.6 cal/m^2 d and the average sunshine duration is 7.2 h/d. In particular, the southeast Anatolia and the Mediterranean regions are favorable for solar energy use [25]. Generally, solar energy is used for heating and the consumption of solar energy has increased from 5 ktoe in 1986 [25] to 375 ktoe in 2004 [32]. In 2010, Turkey's solar energy production is expected to be 600 ktoe [33].

2.5. *Biomass resources*

Due to the prevailing geographical and meteorological conditions, Turkey is very suitable for forestry and agriculture. The sum of the agricultural areas, grasslands and

Table 5
Solar radiation and sunshine duration in various regions of Turkey [25]

Region	Solar radiation (cal/cm^2 d)	Sunshine duration (h/d)
Southeast Anatolia	344.8	8.2
Mediterranean	328.3	8.1
East Anatolia	322.4	7.3
Central Anatolia	310.3	7.2
Aegean	308.0	7.5
Marmara	275.9	6.6
Black Sea	264.5	5.4
Average	309.6	7.2

Table 6
Turkey's annual biomass potential in 2001 [20,34–37]

Biomass	Annual potential (Mt)	Energy value (Mtoe)
Annual crops	55	14.9
Perennial crops	16	4.1
Forest residues	18	5.4
Residues from agro-industry	10	3.0
Residues from wood industry	6	1.8
Animal wastes	7	1.5
Other	5	1.3
Total	117	32.0

Mtoe: Million tons of oil equivalents; Mt: Million tons.

forests constitute 93.6% of the total area of Turkey. The annual average biomass yield of forests is estimated to be 188 million tons (Mt), followed by agricultural areas at 180 Mt and grasslands at 174 Mt. This represents a total dry biomass of 542 Mt annually [30].

The annual biomass potential of Turkey is approximately 32 million tons oil equivalents (Mtoe). The total recoverable bioenergy potential is estimated to be about 16.92 Mtoe. Turkey's annual biomass potential is given in Table 6 [20,34–37]. In recent years, Turkey's main renewable source is biomass and animal waste (67.4% of thermal electrical power stations), but expected to decline in share and absolute terms in the future as the convenience and options of oil, natural gas and liquefied petroleum gas, coal or electrical heating and cooking become available [23].

3. Contribution of renewable sources to electrical power production of Turkey

Turkey's rapid growth in electricity demand, which has led to almost a doubling of installed generating capacity over the past decade, is expected to continue for the foreseeable future [38]. In addition to increasing domestically generated electricity through construction of new power plants, Turkey is looking outside its borders to help meet the country's rapidly growing power demand. The sharp growth of the Turkish energy sector has been accompanied by institutional reforms [39].

According to a law issued in 1971, Turkish Electricity Authority was responsible as a whole for the generation and distribution of electricity throughout the country. The electricity sector in Turkey was dominated by two state-owned companies in 1993: the Turkish Electricity Generation and Transmission Company (TEAS in Turkish initials) and the Turkish Electricity Distribution Company [23].

Restructuring of the electricity sector in Turkey has started with the establishment of the Energy Market Regulatory Authority (EMRA) upon law No. 4628 which came into force on 3 March 2001. The Energy Market Regulatory Board, which runs the EMRA, was commissioned on 19 November 2001. In May 2002, the EMRA issued drafts of the Energy Market Licensing Regulation and the Electricity Market Tariffs Regulation, and these regulations went into effect in August 2002. The Electricity Market Implementation Manual was issued by the EMRA in April 2003 [40].

In 2005, total gross electricity production of Turkey has reached about 161.5 terawatt-hours (TWh), 74% of this is produced from thermal power plants, 24.6% from HEPPs and the remainder 1.4% from others (Fig. 1) [41]. Turkish electricity generation is mainly derived from natural gas, hydraulic, coal and lignite sources (Table 7). The share of illumination within the electricity consumption is increasing every year. Electricity demand in Turkey is growing rapidly, with the rate of increase of 8% on average for many years [23]. Fig. 2 shows the electricity production and consumption in Turkey between 1995 and 2005. Electricity is a major component of increased energy demand in the industry, household and trading establishment sectors. In 2005, Turkey's electricity demand distribution according to sectors is shown in Fig. 3.

Total installed capacity reached to 38,820 MW by the end of 2005 [42]. Fig. 4 shows development of total installed capacity between 1970 and 2005. If forecasts prove correct, Turkey may need to triple its total installed capacity, to around 109 giga-watt-hours (GWh), by 2020. Turkey's electric capacity development in the near future is given in Table 8.

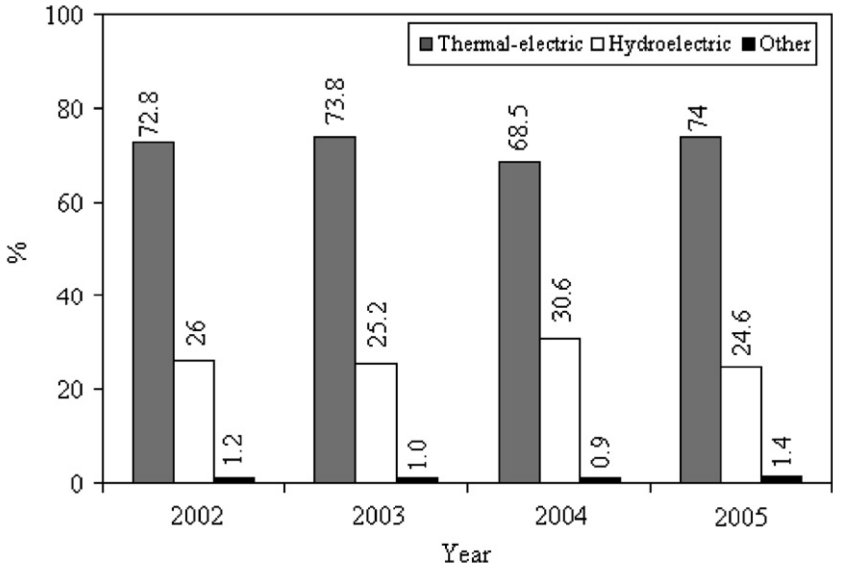


Fig. 1. Share of thermal, hydro and other sources in Turkish electricity generation between 2002 and 2005.

Table 7
Turkish electricity generation in 2005 [41]

	Energy (TWh)	Percentage (%)
Natural gas	70.8	43.8
Lignite	30	18.6
Coal	13	8
Hydroelectric	39.7	24.6
Oil	5.8	3.6
Other	2.2	1.4
Total	161.5	100.0

TWh: terawatt-hours.

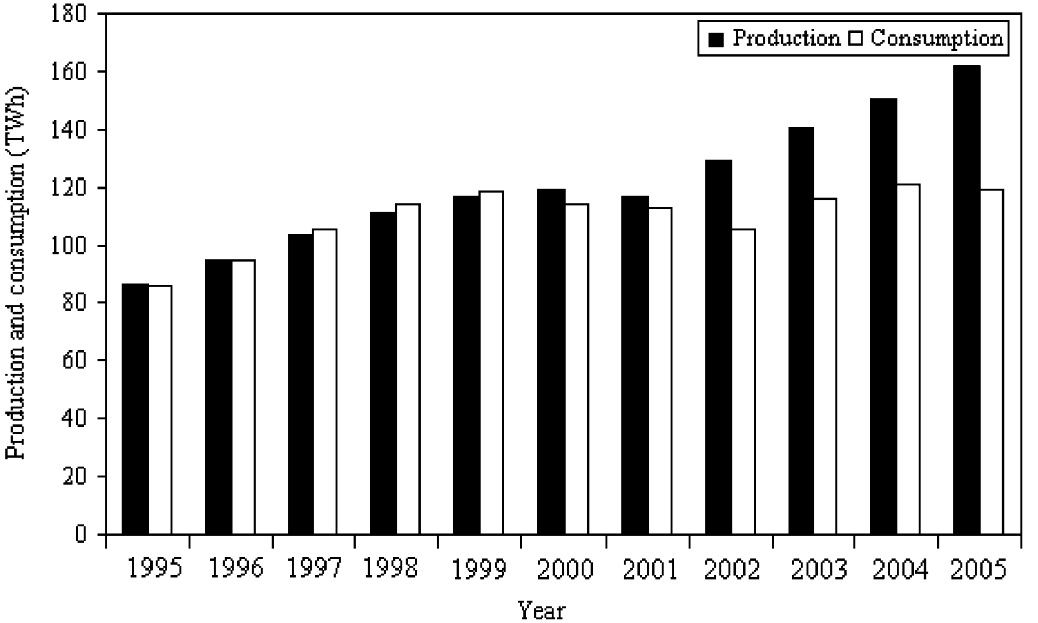


Fig. 2. The electricity production and consumption in Turkey between 1995 and 2005 [41].

In the case of biomass, solar, geothermal and wind energy, there is an important potential for domestic heating and electricity generation [43]. Presently, Turkey does not have any demonstrated success in renewable energy except hydroelectric energy [20]. Table 9 shows roughly overall conversion efficiencies from renewables to electricity.

Turkey has a total gross hydroelectric power potential of 433,000 GWh, but only 127,000 GWh of the total hydroelectric potential of Turkey can be economically used [44]. Table 10 shows Turkey's hydroelectric power and small hydroelectric power potential [44,45]. By the commissioning of new HEPPs, which are under construction, 36% of the economically usable potential of the country would be tapped [46]. In 2005, the share of

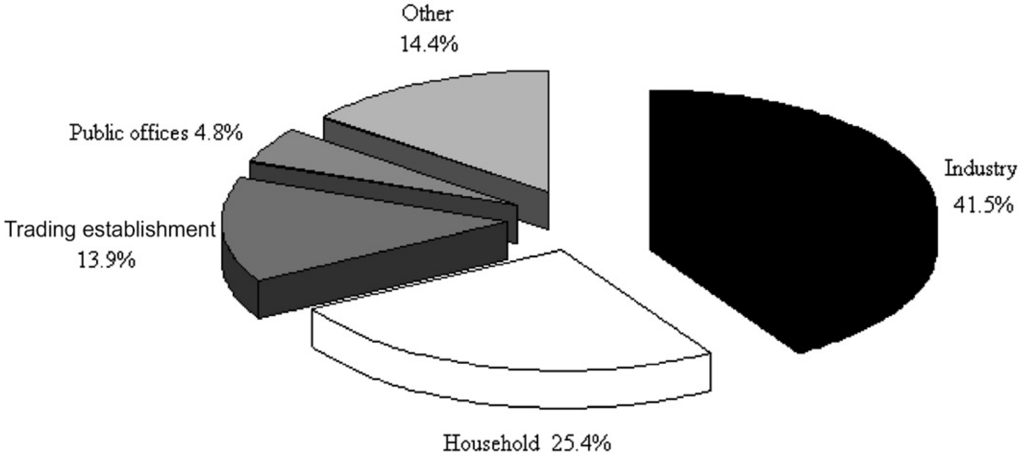


Fig. 3. Turkey's electricity demand distribution according to sectors in 2005 [41].

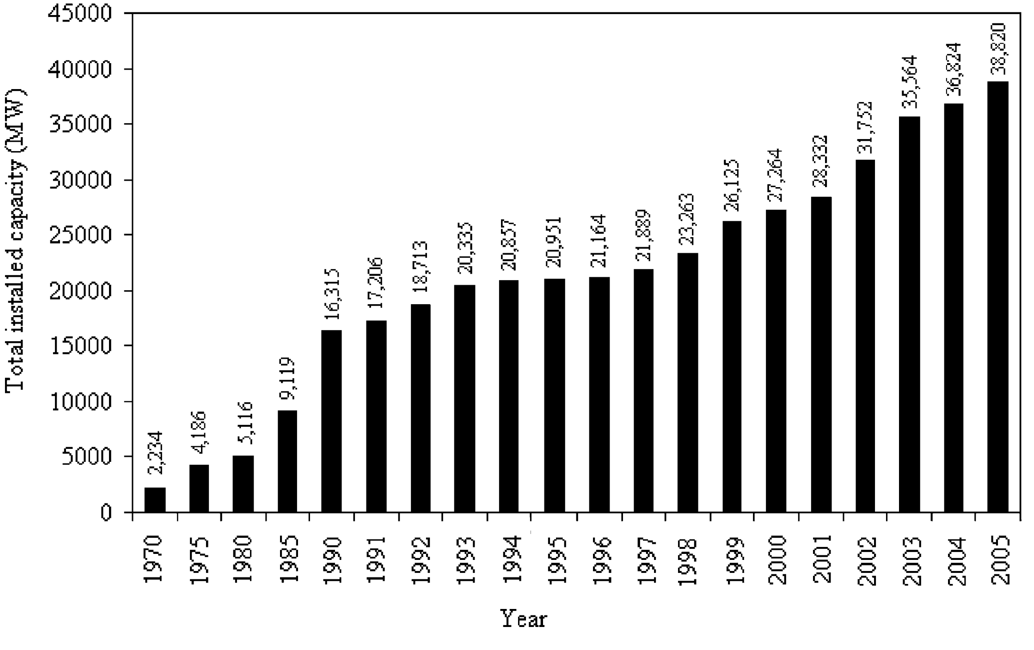


Fig. 4. Total installed capacity in Turkey between 1970 and 2005 [42].

hydroelectric is about 24.6% (39.7 TWh) of total production of the country [41]. Turkey is falling short of electricity as the water levels in major HEPPs, Ataturk, Karakaya and Keban are dropping to critical levels with lessening rainfalls. Urgent energy programs are needed for quick implementation [23]. Over the next three decades, it is expected that many foreign investors and financiers will be interested in the Turkish hydropower market [16].

Geothermal energy should be available in Turkey since it lies astride deep geological faults, and could be utilized, in selected locations, to cover a share of electricity demand.

Table 8
Turkey's electric capacity development in the near future [23]

Energy source	2010		2020	
	Installed capacity (MW)	Generation (GWh)	Installed capacity (MW)	Generation (GWh)
Hydro and other renewables	24,982	85,719	30,031	104,043
Natural gas	18,856	125,548	34,256	225,648
Coal	16,106	104,035	26,906	14,235
Fuel oil and diesel	3125	17,993	8025	49,842
Nuclear	2000	14,000	10,000	70,000
Total	65,069	347,925	109,218	463,768

Table 9
The overall conversion efficiencies from renewables to electricity [23]

Electricity from	Overall conversion efficiency (%)
Biomass fired plant	25–40
Biogas ignition gas engine	10–16
Hydropower plant	65–85
Geothermal hot fluid (temperature more than 473 K)	40–60

Table 10
Turkey's hydropower and small hydropower potential [44]* and [45]**

	Gross theoretical potential (GWh)	Technically feasible potential (GWh)	Economically feasible potential (GWh)
HEPP*	433,000	216,000	127,381
SHP**	50,000	30,000	20,000

HEPP, hydroelectric power plant; SHP, small hydropower plant.

Geothermal electricity generation has a minor role in Turkey's electricity capacity, as low as 0.09%, but the projections foresee an improvement to 0.32% by the year 2020 [23]. Geothermal electricity production for the year 2005 is only 94 GWh [32]. It is planned to generate 500 MWe geothermal energy by 2010 and 1000 MWe energy by 2020 in the plants to be set up in the fields that are suitable for electricity generation [21]. Turkey has extended its involvement in geothermal energy projects, supported by loans from the Ministry of Environment, and geothermal energy is expected to increase substantially in the coming years [16].

Although there are an appreciable number of windy days in many parts of Turkey, the possibility of wind energy generation assessment has not been completed yet and, therefore, local research is on-going [30,47]. Electricity produced from wind energy between 1998 and 2005 in Turkey amounts to 345 GWh. The installed capacity of wind energy is expected to reach 51 MW by 2005 and 11,200 MW by 2025 [23], where the share

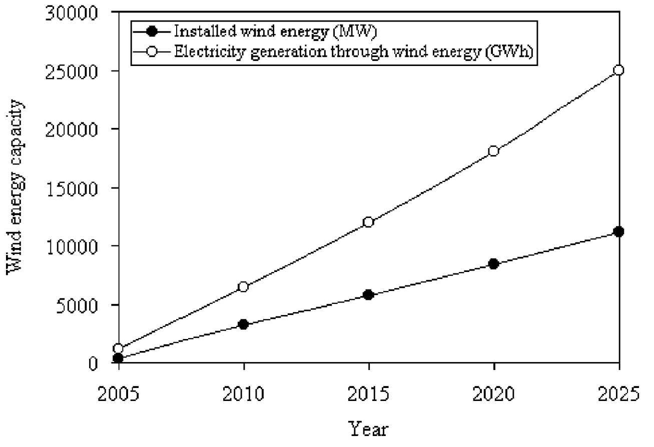


Fig. 5. Plots for estimated wind energy capacities of Turkey between 2005 and 2025 [26,29].

of wind energy for generating electricity would increase from 0.04% to 3.6%. Fig. 5 shows the plots for estimated wind energy capacities of Turkey between 2005 and 2025. Considering the development of wind energy in the country, it may be concluded that the number of the wind power plant installations will considerably increase in the future [30]. Turkish Wind Energy Association plans a new project on preparation of wind atlas of Turkey. This project will be carried out jointly by state meteorological service (DMI), General Directorate of Electrical Power Resources Survey and Development Administration (EIE) and Bilkent University Communication and Spectrum Management Research centre (ISYAM). The primary objectives of this project are [48]:

- to establish reference for the central, regional and local authority in wind energy planning;
- to define the areas where wind energy can make an economic contribution;
- to provide a reliable picture of the overall and general distribution of the wind resources in Turkey.

Solar photovoltaic applications in Turkey are solely limited with some state organizations which use photovoltaic for meeting remote electricity demand. Main application areas include the telecom stations, fire observation stations, lighthouses and highway emergency systems [20,33]. The first photovoltaic-powered water pumping system was applied in the Solar Energy Institute of Ege University, Izmir in 1988. The number of photovoltaic applications has increased in the late 1990s [30]. Solar photovoltaic and solar–thermal power are still in the demonstration stage and not quite competitive as yet. Clearly, both solar–thermal and photovoltaic systems could be used to great effect. Three-fourths of the economically usable potential is efficient for thermal use and the remainder for electricity production [23].

Biomass is used to meet a variety of energy needs, including generating electricity [16]. The electricity is produced by direct combustion of biomass, advanced gasification and pyrolysis technologies are almost ready for commercial scale use [35,37]. The amount of usable biomass potential of Turkey is approximately 6.2 GW. The electrical production

from usable biomass has a net impact of $1.8 billion [16,34]. One project of Turkey's biomass power project is water development in Adana province. This project's installed capacity is 45 MW [20,35,36]. Two others, at a total capacity of 30 MW, are are at the feasibility study stage in Mersin and Tarsus provinces [7,20]. A US firm will establish a 10 MW capacity BOT power plant in Ankara–Mamak, which will use landfill gas generated by garbage. Similar potential exists in large municipalities such as Istanbul, Izmir, Bursa, Adana and Antalya. The electrical production from usable biomass (about 17 Mtoe/year) has a net impact of $4.4 billion in personal and corporate income and represented more than 160,000 jobs in Turkey [20]. In the last decade, many new biomass power plants have been built and the development of new technologies for biomass-based power generation is proceeding. However, high alkali content in biomass can form compounds with low melting temperature during combustion. The low melting ash constituents can induce in-bed-agglomeration, in addition to fouling and corrosion problems [7].

Resource estimation studies of new and renewable energy sources for electricity production are currently being carried out by relevant bodies. Preliminary data show that Marmara, the Aegean and the Southeast Anatolian regions of Turkey are rich in wind energy, Southeast and Mediterranean Regions in solar energy, Aegean and Marmara regions in geothermal energy and East Black Sea region in small and micro hydropower. Heavily populated towns are assumed to have biomass potential, which can be used for electricity production [39].

4. Conclusion

Green energy sources usually include renewable energy sources. This work shows that Turkey's renewable energy potential is especially very important. But, the renewable energy contribution in the total primary energy production is insignificant. Presently, Turkey does not have any demonstrated success in renewable energy except hydroelectric energy. The renewable energy systems have been neglected so far in Turkey but must be included in the new energy programs.

Over the next three decades, it is expected that many foreign investors and financiers will be interested in the Turkish hydropower market. Turkey has extended its involvement in geothermal energy projects, supported by loans from the Ministry of Environment, and geothermal energy is expected to increase substantially in the coming years. Considering the development of wind energy in the country, it may be concluded that the number of the wind power plant installations will considerably increase in the future. The installed capacity of wind energy is expected to reach 51 MW by 2005 and 11,200 MW by 2025, where the share of wind energy for generating electricity would increase from 0.04% to 3.6%.

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